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**AFPTEF REPORT NO. 08-R-02
AFPTEF PROJECT NO. 06-P-105**

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**Development of the MQ-9 Reaper Propeller Container,
CNU-690/E**

**AFMC LSO/LOP
AIR FORCE PACKAGING TECHNOLOGY & ENGINEERING FACILITY
WRIGHT PATTERSON AFB, OH 45433-5540
21 February 2008**

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AFPTEF PROJECT NO. 06-P-105

TITLE: Development of the MQ-9 Reaper Propeller Container

ABSTRACT

The Air Force Packaging Technology Engineering Facility (AFPTEF) was tasked with the design of a new shipping and storage container for the MQ-9 Reaper Propeller in March of 2006. The new container is designed to replace the fiberglass container currently used.

The current container provides minimal shock protection and being fiberglass is susceptible to deformation, delamination, and extreme temperatures. Additionally, the fiberglass container can not house the propeller and spinner when the spinner is disassembled, the preferred shipping configuration. AFPTEF used proven design techniques to meet these design requirements.

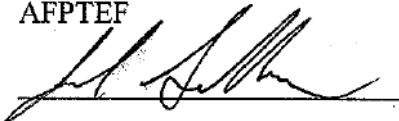
The CNU-690/E, designed to SAE ARP1967A, is an aluminum, long-life, controlled breathing, reusable shipping and storage container. The new container protects the Propeller mechanically and environmentally. The container passed all qualification tests per ASTM D4169.

The CNU-690/E container not only meets user requirements but also provides an economic saving for the Air Force. The savings will be thousands of dollars per Propeller over the twenty-year life span of the container.

Total man-hours: 1400

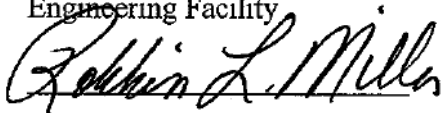
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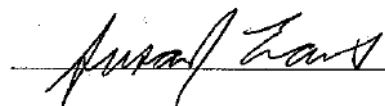
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PUBLICATION DATE:



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INTRODUCTION

BACKGROUND – Reaper program office personnel at Wright-Patterson AFB contacted AFPTEF to request the design of a reusable container for the MQ-9 Reaper Propeller that would eliminate current shipping and storage risks. The Reaper Propeller is currently shipped in a fiberglass container. The fiberglass design is susceptible to deformation under constant load and cracking under extreme temperatures, either of which could easily cause a seal failure. Delamination is also a concern if the container is constantly exposed to UV rays, such as sunlight. These factors could lead to a corrosion problem for the propeller. The container supplies little shock protection and can not house the propeller and spinner when disassembled. The Reaper Propeller container is one of a family of new AFPTEF container designs that better protect items during the shipping and storage cycle. Containers were also designed for the Reaper Fuselage, Reaper Wings and Reaper Engine.

REQUIREMENTS – AFPTEF, Program Office personnel and General Atomics agreed upon a list of requirements during initial design discussions. Many of these requirements were not met by the fiberglass container. The requirements are as follows:

- Sealed/controlled-breathing container that protects against varied environmental conditions and weather during either inside or outside shipping and storage
- Propeller shock/vibration limited to 20 Gs
- Reusable and designed for long life (20 years)
- Designed for disassembled Propeller & Spinner
- Low maintenance
- Field repairable hardware
- Forklift capabilities (Base & Cover)
- No loose packing material

DEVELOPMENT

DESIGN – The Reaper Propeller Shipping and Storage Container (CNU-690/E) design meets all the users' requirements. The CNU-690/E is a sealed, welded aluminum, controlled breathing, reusable container (Appendix 2, Figure 1). The container is engineered for the physical and environmental protection of the Propeller during worldwide transportation and storage. The container consists of a base and a completely removable cover equipped with the special features listed below. The cover is designed to be removed by forklift only (Appendix 2, Figure 2), per the customer's request. Guide posts (Appendix 2, Figure 4) keep the cover from coming in contact with the Engine during cover removal and replacement. The base is a one piece skid/double walled base extrusion with 4-way enclosed forklift openings, humidity indicator, pressure equalizing valve (1.5 psi pressure/ 1.5 psi vacuum), internal document holder and a desiccant port for easy replacement of desiccant (controls dehumidification). A silicone rubber gasket and quick release cam-over-center latches create a water/air-tight seal at the base-cover interface. Container external dimensions are 107.0 inches length, 93.8 inches width, and

36.2 inches height. Container empty weight is 1301 pounds, and 1454 pounds with the propeller in place.

A foam isolation system is integrated into the base and provides shock and vibration protection to 20 G's (Appendix 2, Figure 4). The propeller hub rests on a high density polyethylene load spreader that is integrated into the center foam assembly (Appendix 2, Figure 4). The hole pattern in the load spreader follows the pin pattern on the propeller hub (Appendix 2, Figure 5). The blades "float" over six foam assemblies and are held in place by six heavy duty Velcro straps (Appendix 2, Figure 3). The blades do not rest on the foam assemblies due to static stress loading requirements, but help to prevent damage during loading and unloading. All vibration and impact is mitigated by the center foam assembly. The spinner and its parts are secured in the two spinner parts boxes (Appendix 2, Figures 6 & 7). There are no detachable parts on the container other than the container lid, which eliminates FOD risks.

REAPER ENGINE CONTAINER FEATURES	
Pressure Equalizing Valve	2
Humidity Indicator	1
Desiccant Port	1
Internal Document Receptacle	1
Forkliftable (Base & Cover)	Yes
Cover Latches	24
Cover Lift Handles	None
Cover Lift Rings	None
Cover Tether Rings	None
Base Lift Handles	None
Base Tie-down Rings	8
Stacking Capability	Yes

PROTOTYPE – AFPTEF fabricated one CNU-690/E prototype container in house for testing. The prototype container was fabricated in accordance with (IAW) all requirements and tolerances of the container drawing package. The drawing package used for prototype fabrication has been released for the manufacture of production quantities of the container. Each face of the container was uniquely identified for testing identification as shown below.

DESIGNATED SIDE	CONTAINER FEATURE
Top	Cover Top
Aft	Desiccant Port
Right	Right Side from Aft
Left	Left Side from Aft
Forward	Opposite Aft
Bottom	Base Bottom

QUALIFICATION TESTING

TEST LOAD – The test load was a functioning Reaper propeller (Appendix 2, Figure 3). The triaxial accelerometer used to record actual accelerations sustained by the propeller was mounted on the propeller hub (Appendix 2, Figures 8 & 9). The test load weight was 153 pounds.

TEST PLAN – The test plan primary references were ASTM D 4169 and SAE ARP 1967 (Appendix 1). The test methods specified in this test plan constituted the procedure for performing the tests on the container. The performance criteria for evaluation of container acceptability were specified at 20 Gs maximum and an initial and final leak rate of 0.05 psi per hour at 1.5 psi. These tests are commonly applied to special shipping containers providing rough handling protection to sensitive items. The tests were performed at AFPTEF, Building 70, Area C, Wright-Patterson AFB.

ITEM INSTRUMENTATION – The test load was instrumented with a piezoelectric triaxial accelerometer mounted on the propeller hub as close to the center of mass as possible (Appendix 2, Figures 8 & 9). The shape of the propeller and its orientation in the container resulted in the following accelerometer axis orientations:

- X Axis - Directed through container Aft Right corner.
- Y Axis - Directed through container Forward Right corner.
- Z Axis - Directed through container Top and Bottom sides (Vertical motion).

See Appendix 4 for detailed accelerometer and other instrumentation information.

TEST SEQUENCES – Note: Test sequences were performed at the temperature and humidities described in the test procedure.

TEST SEQUENCE 1 – Leak Test

Procedure – The desiccant port cover was removed and replaced with a port cover modified for attachment of the digital manometer and vacuum/pressure pump lines. The container was closed and sealed. The leak test was conducted at ambient temperature and pressure. The pneumatic pressure leak technique was used to pressurize the container to a minimum test pressure of 1.5 psi. Maximum allowable leak rate is 0.05 psi per hour. (Appendix 2, Figure 10).

Results – The container passed the leak test with a leak rate less than the maximum allowed rate of 0.05 psi per hour.

TEST SEQUENCE 2 – Vacuum Retention Test

Procedure – The desiccant port cover was removed and replaced with a port cover modified for attachment of the digital manometer and vacuum/pressure pump lines. The container was closed and sealed. The vacuum retention test was conducted at ambient temperature and pressure. The air inside the container was

evacuated to a minimum vacuum of -1.5 psi. Maximum allowable pressure increase rate is 0.05 psi per hour. (Appendix 2, Figure 10).

Results – The container passed the vacuum retention test with a pressure increase rate less than the maximum allowed rate of 0.05 psi per hour.

TEST SEQUENCE 3 – Rotational Drops, -40°C (-40°F)

Procedure – The container with the item inside was placed inside an environmental chamber on a 1-inch steel floor and allowed to soak for 24 hours at -40°C; the rotational drops were performed at the end of this soak period. At the customer's request, a drop height of 15 inches (12 inches is the standard drop height for this size container) was used to perform two diagonally opposite corner drops (Aft-right and Forward-left) and two adjacent bottom edge drops (Aft and Left) onto the steel chamber floor, and the impact levels were recorded. The maximum allowed impact level for the item was 20 Gs. (Appendix 2, Figure 11)

Results – Three of the recorded resultant G data impact peaks exceeded the maximum allowable 20 Gs. The aft bottom edge, the aft-right corner and the forward-left corner had resultant Gs of 24, 21 and 24 respectively. Due to the use of foam cushioning, these were the lowest achievable impact levels that could be achieved. The propeller was carefully examined after testing by the manufacturer and no damage was found. These G-levels are therefore deemed acceptable.

There was no damage to either the container or the item as a result of the testing. The container met the test requirements. (Appendix 3, Table 1 and Waveforms.)

TEST SEQUENCE 4 – Rotational Drops, +60°C (+140°F)

Procedure – The container was allowed to soak in the same environmental chamber for 24 hours at +60°C; Test Sequence 1 was repeated at the end of this soak period on the two unimpacted corners (Aft-left and Forward-right) and bottom edges (Forward and Right). (Appendix 2, Figure 12)

Results – All of the recorded resultant impact peak G data was equal to or less than the maximum allowed 20 Gs. There was no damage to either the container or the item as a result of the testing. The container met the test requirements. (Appendix 3, Table 1 and Waveforms.)

TEST SEQUENCE 5 – Lateral Impact (Pendulum Impact), -40°C (-40°F)

Procedure – The container was allowed to soak in the environmental chamber at -45°C for 24 hours (a lower soak temperature was used to ensure that the contents would remain as close as possible to the required test temperature throughout impact testing). At the end of the soak period, the container was removed from the chamber, quickly moved to the pendulum test apparatus and impacted once on two adjacent sides (Aft and Right). The container impact velocity was 7.3 ft/s. (Appendix 2, Figure 13)

Results – All recorded resultant impact peak G data were equal to or less than the maximum allowed 20 Gs. There was no damage to either the container or the item. The container met the test requirements. (Appendix 3, Table 1 and Waveforms.)

TEST SEQUENCE 6 – Lateral Impact (Pendulum Impact), +60°C (+140°F)

Procedure – The container was allowed to soak in the environmental chamber at +65°C for 24 hours (a higher soak temperature was used to ensure that the contents would remain as close as possible to the required test temperature throughout impact testing). At the end of the soak period, the container was removed from the chamber, quickly moved to the pendulum test apparatus and impacted once on two unimpacted adjacent sides (Forward and Left). The container impact velocity was 7.3 ft/s. (Appendix 2, Figure 14)

Results – All recorded resultant impact peak G data were equal to or less than the maximum allowed 20 Gs. There was no damage to either the container or the item. The container met the test requirements. (Appendix 3, Table 1 and Waveforms.)

TEST SEQUENCE 7 – Leak Test

Procedure – Test Sequence 1 was repeated.

Results – The container passed the leak test with a leak rate less than the maximum allowed rate of 0.05 psi per hour.

TEST SEQUENCE 8 – Vacuum Retention Test

Procedure – Test Sequence 2 was repeated.

Results – The container passed the vacuum retention test with a pressure increase rate less than the maximum allowed rate of 0.05 psi per hour.

TEST CONCLUSIONS – No damage occurred during the above testing to the container, foam isolation system or test item. All impact levels are at or below the item fragility limit of 20 Gs, with the exceptions explained above. Therefore, the container and mounting system do provide adequate protection for the propeller.

FIT & FUNCTION TESTING

Fit and function testing was completed on site at AFPTEF with the Reaper Propeller that was supplied for prototype testing.

CONCLUSIONS

No damage occurred during the above testing to the container, cushioning system or test item. All impact levels are below the item fragility limit of 20 G's with the exceptions of the occurrences outlined above. The CNU-690/E aluminum container was accepted by the Predator Program Office at Wright-Patterson AFB. The container met all the user's requirements. The container can protect a Reaper Propeller during world-wide transportation and storage and will save the Air Force tens of thousands of dollars in O&M costs. In addition the containers now meet program rapid deployment and operational requirements.

RECOMMENDATIONS

AFPTEF recommends that new containers be procured and delivered to avoid damage to Reaper Propellers currently in the logistics cycle, thus mitigating overall shipping risks. All fiberglass containers for the Reaper Engine should be replaced.

APPENDIX 1: Test Plan

AF PACKAGING TECHNOLOGY AND ENGINEERING FACILITY (Container Test Plan)					AFPTEF PROJECT NUMBER: 06-P-105	
CONTAINER SIZE (L x W x D) INTERIOR:		EXTERIOR:		WEIGHT GROSS:	ITEM:	CUBE (CU. F)
106.5 x 93.3 x 31.2		107.0 x 93.8 x 36.2		1454	153	209.8
ITEM NAME: MQ-9 Reaper Propeller				MANUFACTURER:		
CONTAINER NAME: Reusable Shipping & Storage Container					CONTAINER COST:	
PACK DESCRIPTION: Extruded Aluminum Container, Test Load of a MQ-9 Reaper Propeller						
CONDITIONING: As noted below						
TEST NO.	REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S	TEST TITLE AND PARAMETERS		CONTAINER ORIENTATION	INSTRUMENTATION	
		<p align="center"><u>NOTE</u></p> <p>No damage to contents is acceptable and Package must be in serviceable condition. Serviceable means remains sealed, with no deformities, etc.</p> <p align="center"><u>Quality Conformance Tests</u></p>				
1.	<u>Examination of Product.</u> SAE ARP 1967 Par. 4.5.1 Table I	Container shall be carefully examined to determine conformance with material, workmanship, and requirements as specified in Table and drawings.		Ambient temp.	Visual Inspection (VI)	
2.	<u>Weight Test.</u> SAE ARP 1967 Par. 4.5.8.3.7	Container shall be weighed.		Ambient temp.	Scale	
		<u>Performance Tests</u>				
3.	<u>Leak Test.</u> SAE ARP 1967 Par. 4.5.2	Pneumatic pressure at 1.5 psi and vacuum retention at 1.5 psi. After temperature stabilization, pressure drop shall not exceed 0.05 psi per hour. Perform leak test again at end of test series.		Ambient temp.	Water Manometer (WM) or Pressure Transducer (PT)	
COMMENTS:						
PREPARED BY: Joel A. Sullivan, Mechanical Engineer				APPROVED BY: Robbin L. Miller, Chief AFPTEF		

AF PACKAGING TECHNOLOGY AND ENGINEERING FACILITY (Container Test Plan)					AFPTEF PROJECT NUMBER: 06-P-105	
CONTAINER SIZE (L x W x D) INTERIOR:		EXTERIOR:		WEIGHT GROSS:	ITEM:	CUBE (CU. F)
106.5 x 93.3 x 31.2		107.0 x 93.8 x 36.2		1454	153	209.8
ITEM NAME: MQ-9 Reaper Propeller				MANUFACTURER:		
CONTAINER NAME: Reusable Shipping & Storage Container					CONTAINER COST:	
PACK DESCRIPTION: Extruded Aluminum Container, Test Load of a MQ-9 Reaper Propeller						
CONDITIONING: As noted below						
TEST NO.	REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S	TEST TITLE AND PARAMETERS		CONTAINER ORIENTATION	INSTRUMENTATION	
4.	<u>Rotational Drop Tests (Low Temperature).</u> SAE ARP 1967 Par. 4.5.3 ASTM D 4169 ASTM D 6179 Methods A&B	Condition at -40°C (+0/-12.2) IAW ASTM D 4332 for 24 hours. Drop height shall be 15". Item shall not sustain more than 20G's.		One drop on diagonal bottom corners (2 drops) and one drop on adjacent edges (2 drops).*	VI Tri-axial Accelerometer	
5.	<u>Rotational Drop Tests (High Temperature).</u> SAE ARP 1967 Par. 4.5.3 ASTM D 4169 ASTM D 6179 Methods A&B	Condition at +60°C (+12.2/-0) IAW ASTM D 4332 for 24 hours. Drop height shall be 15". Item shall not sustain more than 20G's.		One drop on diagonal bottom corners (2 drops) and one drop on adjacent edges (2 drops).**	VI Tri-axial Accelerometer	
6.	<u>Lateral Impact Test (Low Temperature).</u> SAE ARP 1967 Par. 4.5.6 ASTM D 4169 ASTM D 880 Procedure B	Condition at -54°C IAW ASTM D 4332 for 24 hours. Impact velocity 7.3 ft/s. Item shall not sustain more than 20G's.		One impact on an end and one on a side (2 impacts).*	VI and Tri-axial Accelerometer	
COMMENTS: *These drops and impacts are opposite those performed in test 5 & 7. **This drop is opposite that performed in test 4.						
PREPARED BY: Joel A. Sullivan, Mechanical Engineer				APPROVED BY: Robbin L. Miller, Chief AFPTEF		

AF PACKAGING TECHNOLOGY AND ENGINEERING FACILITY (Container Test Plan)				AFPTEF PROJECT NUMBER: 06-P-105	
CONTAINER SIZE (L x W x D) INTERIOR: 106.5 x 93.3 x 31.2		EXTERIOR: 107.0 x 93.8 x 36.2		WEIGHT GROSS: 1454	ITEM: 153
CUBE (CU. F) 209.8				QUANTITY: 1	DATE: October 06
ITEM NAME: MQ-9 Reaper Propeller				MANUFACTURER:	
CONTAINER NAME: Reusable Shipping & Storage Container				CONTAINER COST:	
PACK DESCRIPTION: Extruded Aluminum Container, Test Load of a MQ-9 Reaper Propeller					
CONDITIONING: As noted below					
TEST NO.	REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S	TEST TITLE AND PARAMETERS	CONTAINER ORIENTATION	INSTRUMENTATION	
7.	<u>Lateral Impact Test (High Temperature).</u> SAE ARP 1967 Par. 4.5.6 ASTM D 4169 ASTM D 880 Procedure B	Condition at +74°C IAW ASTM D 4332 for 24 hours. Impact velocity 7.3 ft/s. Item shall not sustain more than 20G's.	One impact on an end and one on a side (2 impacts).**	VI and Tri-axial Accelerometer	
8.	<u>Leak Test.</u> SAE ARP 1967 Par. 4.5.2	Pneumatic pressure at 1.5 psi and vacuum retention at 1.5 psi. After temperature stabilization, pressure drop shall not exceed 0.05 psi per hour. Perform leak test again at end of test series.	Ambient temp.	Water Manometer (WM) or Pressure Transducer (PT)	
COMMENTS: **This impact is opposite that performed in test 6.					
PREPARED BY: Joel A. Sullivan, Mechanical Engineer			APPROVED BY: Robbin L. Miller, Chief AFPTEF		

APPENDIX 2: Fabrication & Testing Photographs

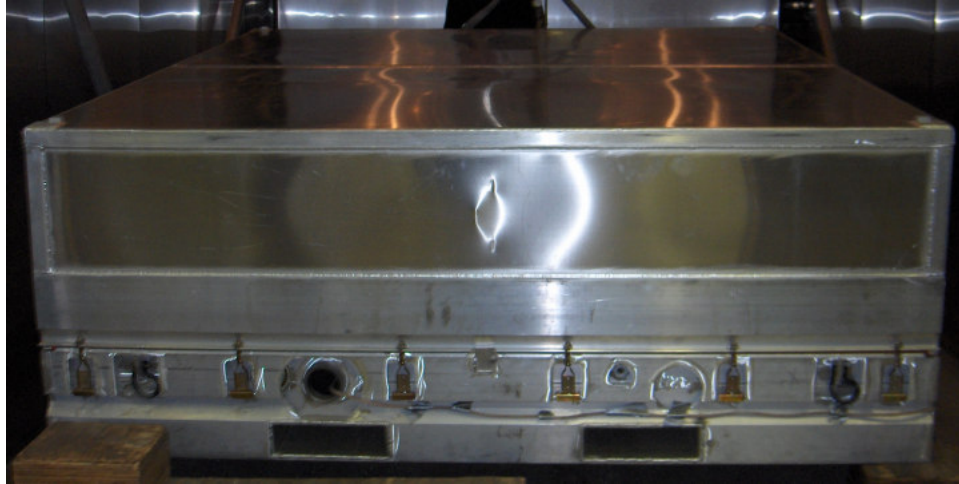


Figure 1. Closed Container.



Figure 2. Container cover with enclosed fork tubes.



Figure 3. Propeller in container base.
(See Figure 4 for current foam configuration)

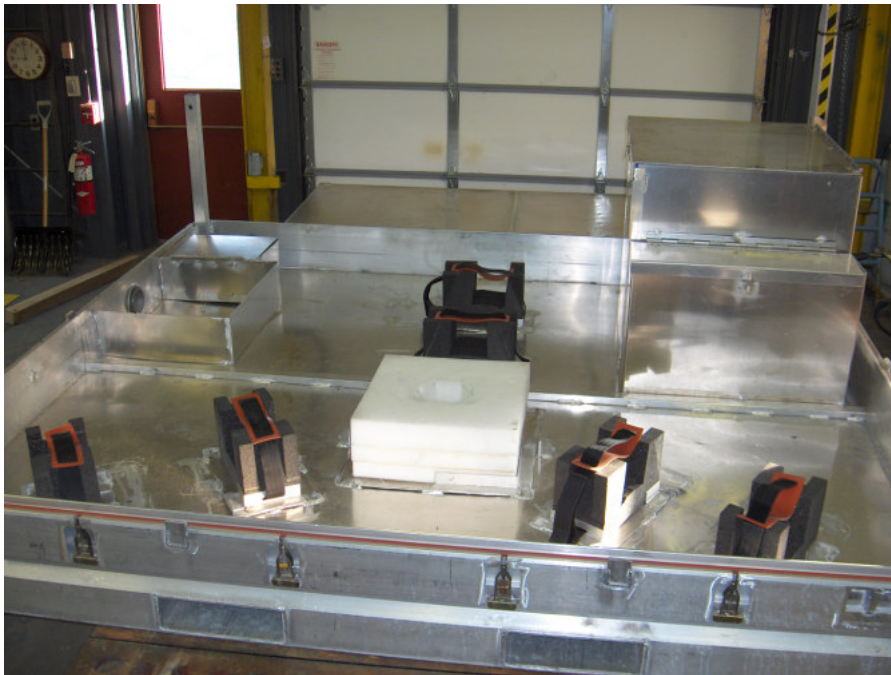


Figure 4. Approved Isolation Assembly Configuration.

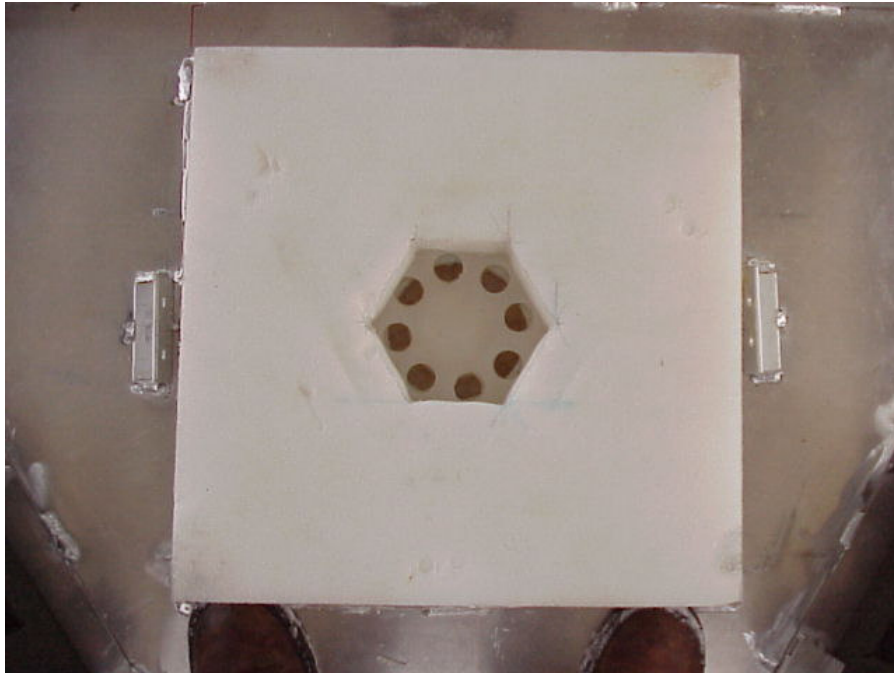


Figure 5. Center Foam Assembly.

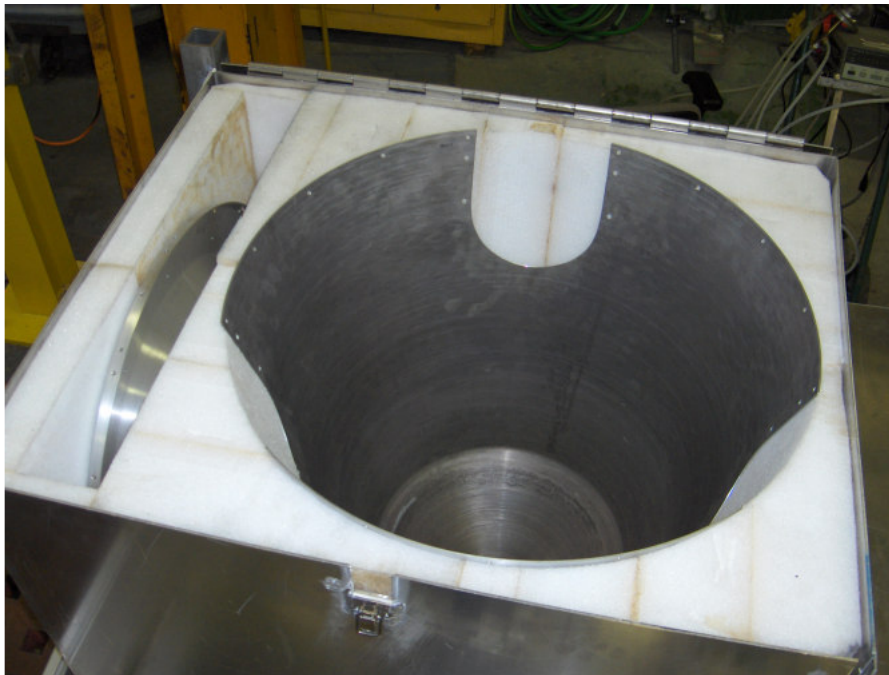


Figure 6. Large Spinner Parts Box.

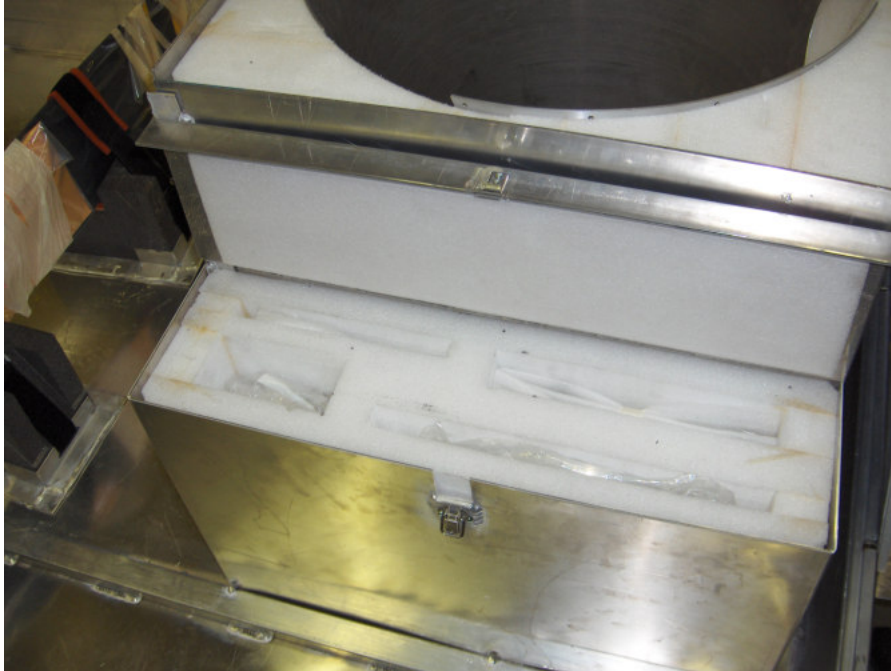


Figure 7. Small Spinner Parts Box.

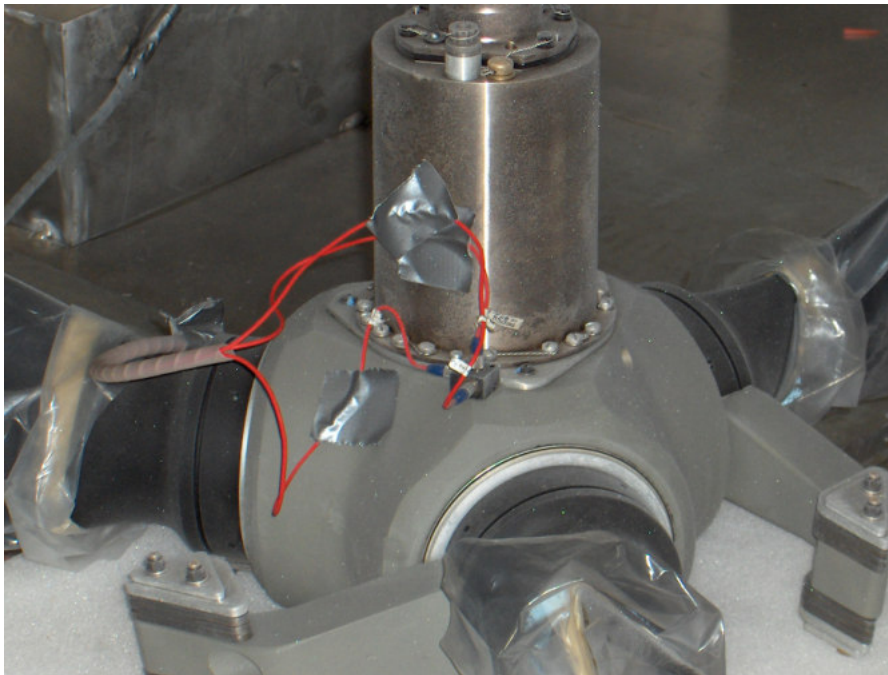


Figure 8. Placement of accelerometer on center propeller housing.



Figure 9. Orientation of accelerometer on propeller in container.



Figure 10. Pressure Test Set-up (for both pressure and vacuum).



Figure 11. Rotational Corner Drop (-40°C).



Figure 12. Rotational Edge Drop (+60°C).



Figure 13. Pendulum Impact Test (-40°C).



Figure 14. Pendulum Impact Test (+60°C).

APPENDIX 3: Test Data

Table 1. Reaper Propeller Impact Test Summary

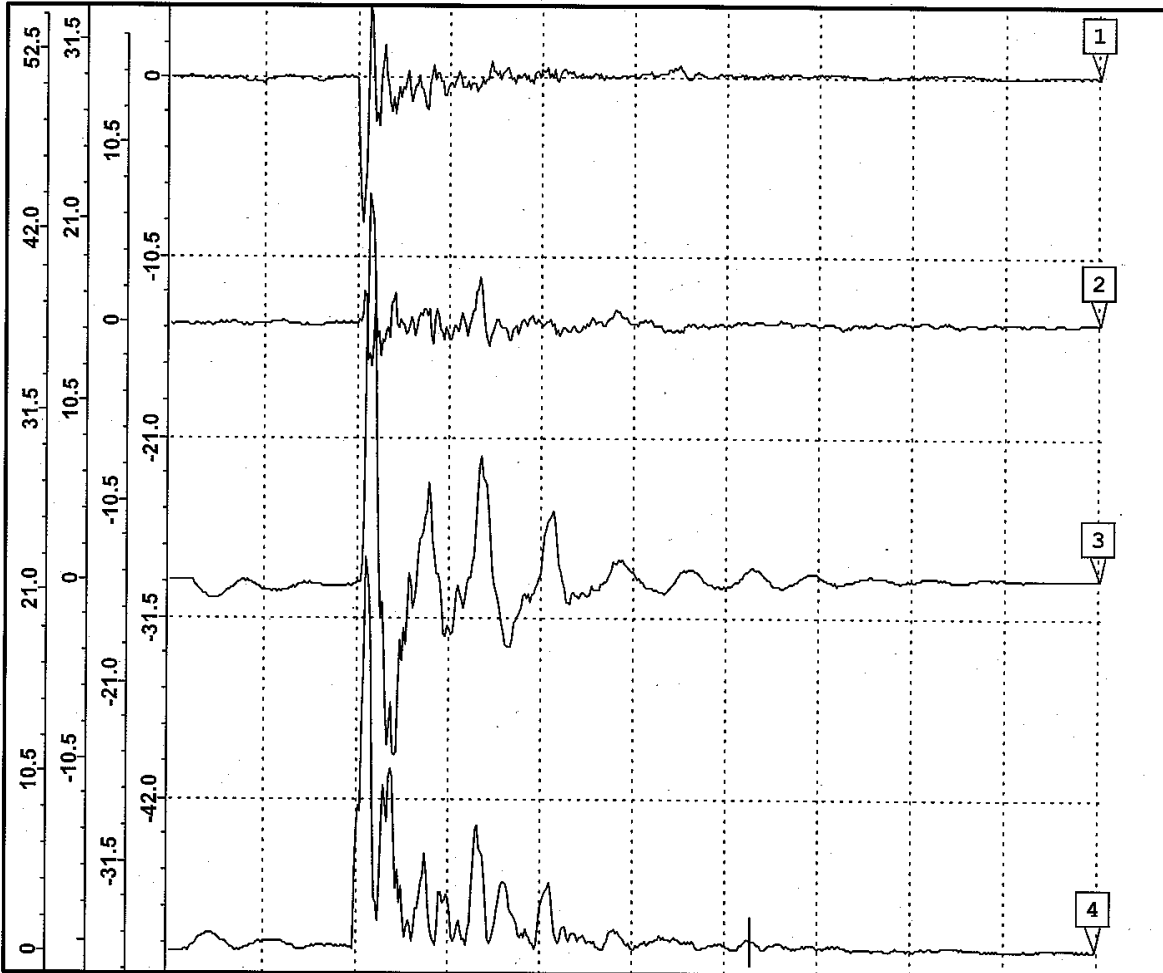
IMPACT TYPE	TEST TEMPERATURE	IMPACT LOCATION	RESULTANT PEAK G
ROTATIONAL - EDGE	-40°F	aft-bottom	24
ROTATIONAL - EDGE	-40°F	left-bottom	19
ROTATIONAL - CORNER	-40°F	aft-right	21
ROTATIONAL - CORNER	-40°F	forward-left	24
ROTATIONAL - EDGE	+140°F	forward-bottom	15
ROTATIONAL - EDGE	+140°F	right-bottom	15
ROTATIONAL - CORNER	+140°F	aft-left	15
ROTATIONAL - CORNER	+140°F	forward-right	20
LATERAL IMPACT - FACE	-40°F	aft	13
LATERAL IMPACT - FACE	-40°F	right	10
LATERAL IMPACT - FACE	+140°F	forward	19
LATERAL IMPACT - FACE	+140°F	left	20

Reaper Propeller

ROTATIONAL DROP TEST

Time: Oct 6 2006 9:28 Test Engineer: Evans
Test Type: Edge, -40°F Impact Point: Aft bottom edge
Container/Item: Aluminum/Propeller Drop Height: 15 inches

V. Angle: 82.21; H. Angle: 94.21;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	819. mS	0.10 g's	-8.48 g's	-35.84 In/s	131 mS	1	2
2	819. mS	-0.05 g's	2.88 g's	-10.40 In/s	131 mS	1	2
3	819. mS	0.73 g's	23.30 g's	9.95 In/s	131 mS	1	2
R	819. mS	0.61 g's	23.54 g's	38.62 In/s	131 mS	1	2

Remarks

Peak Gs X: 8 Y: 3 Z: 23 Peak Gs Resultant: 24

Ch.1=X(aft, right corner); Ch.2=Y(right, frwd corner); Ch.3=Z(vert).
Ch.4=Resultant.

Aft Side = desiccant port side.

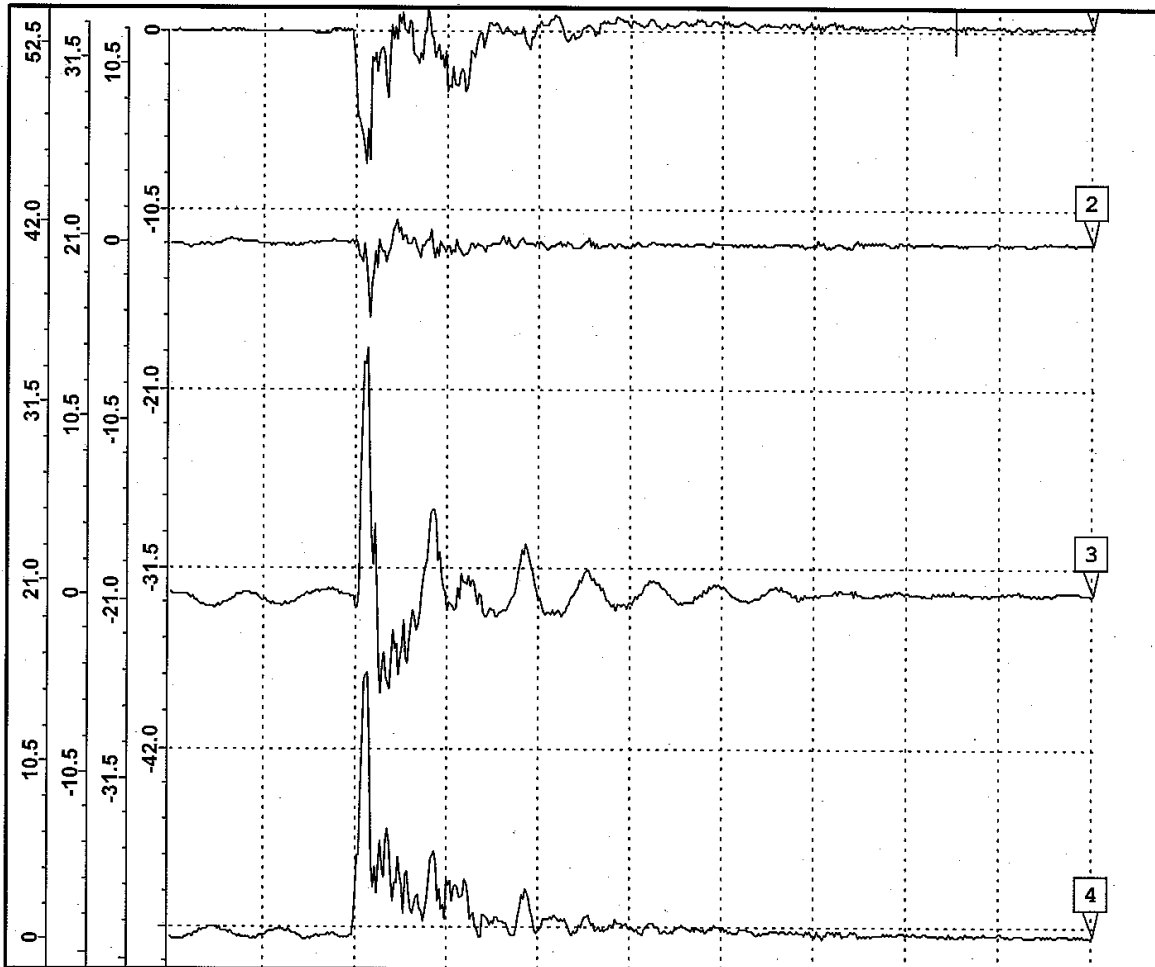
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16471.

Reaper Propeller

ROTATIONAL DROP TEST

Time: Oct 6 2006 10:02 Test Engineer: Evans
Test Type: Edge, -40°F Impact Point: Left bottom edge
Container/Item: Aluminum/Propeller Drop Height: 15 inches

V. Angle: 20.03; H. Angle: 340.43;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	1.11 S	0.12 g's	-9.37 g's	-48.88 In/s	131 mS	1	2
2	1.11 S	0.04 g's	-5.49 g's	-23.41 In/s	131 mS	1	2
3	1.11 S	-0.01 g's	16.95 g's	5.12 In/s	131 mS	1	2
R	1.11 S	0.18 g's	18.65 g's	54.44 In/s	131 mS	1	2

Remarks

Peak G X: 9 Y: 5 Z(vert): 17 Peak G Resultant: 19

Ch.1=X(aft, right corner); Ch.2=Y(right, frwd corner); Ch.3=Z(vert).
Ch.4=Resultant.

Aft Side = desiccant port side.

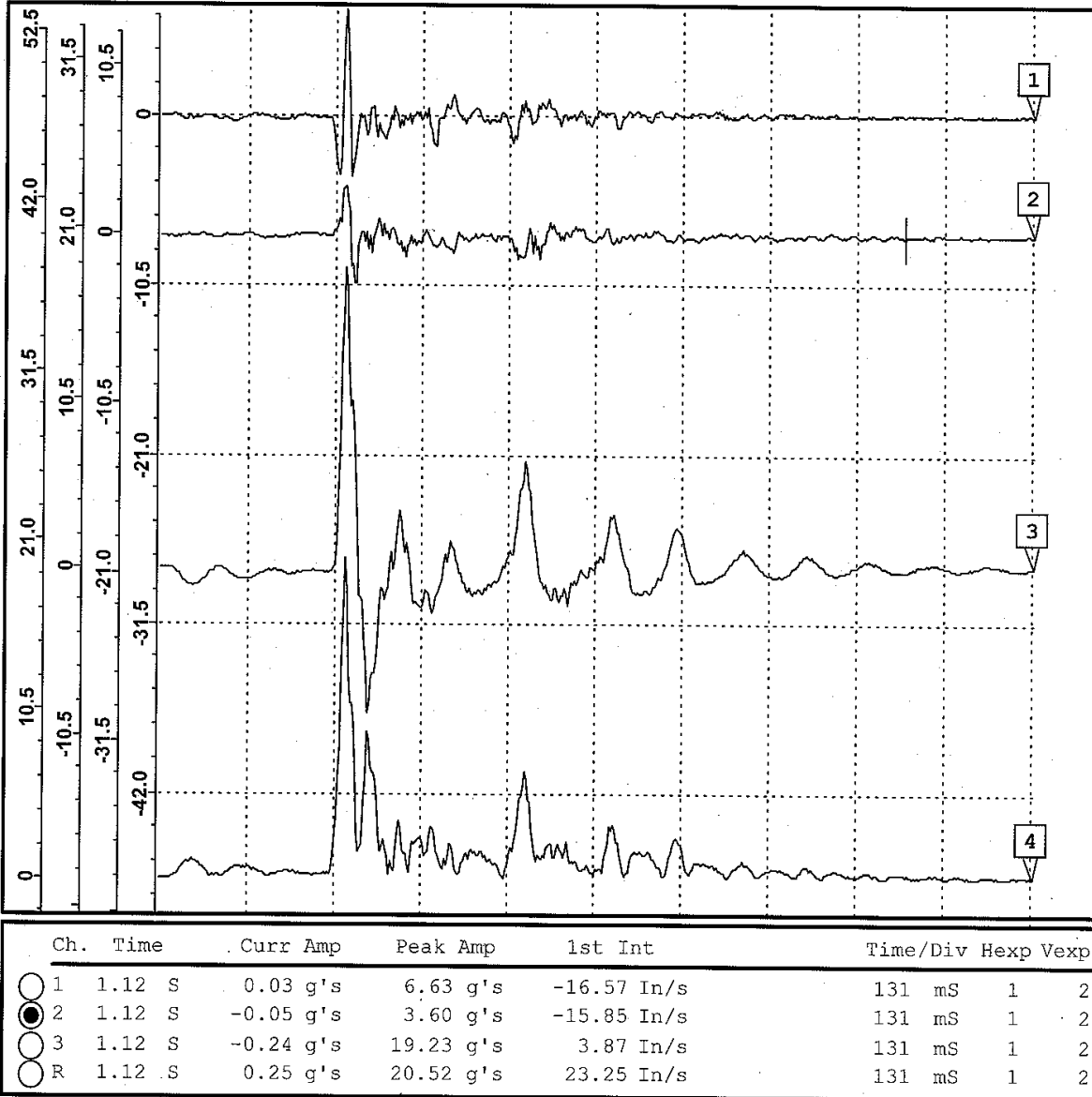
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16471.

Reaper Propeller

ROTATIONAL DROP TEST

Time: Oct 6 2006 9:19 Test Engineer: Evans
Test Type: Corner, -40°F Impact Point: Aft right corner
Container/Item: Aluminum/Propeller Drop Height: 15 inches

V. Angle: 83.40; H. Angle: 257.73;



Remarks:

Peak Gs X: 7 Y: 4 Z: 19 Peak Gs Resultant: 21

Ch.1=X(aft, right corner); Ch.2=Y(right, frwd corner); Ch.3=Z(vert).
Ch.4=Resultant.

Aft Side = desiccant port side.

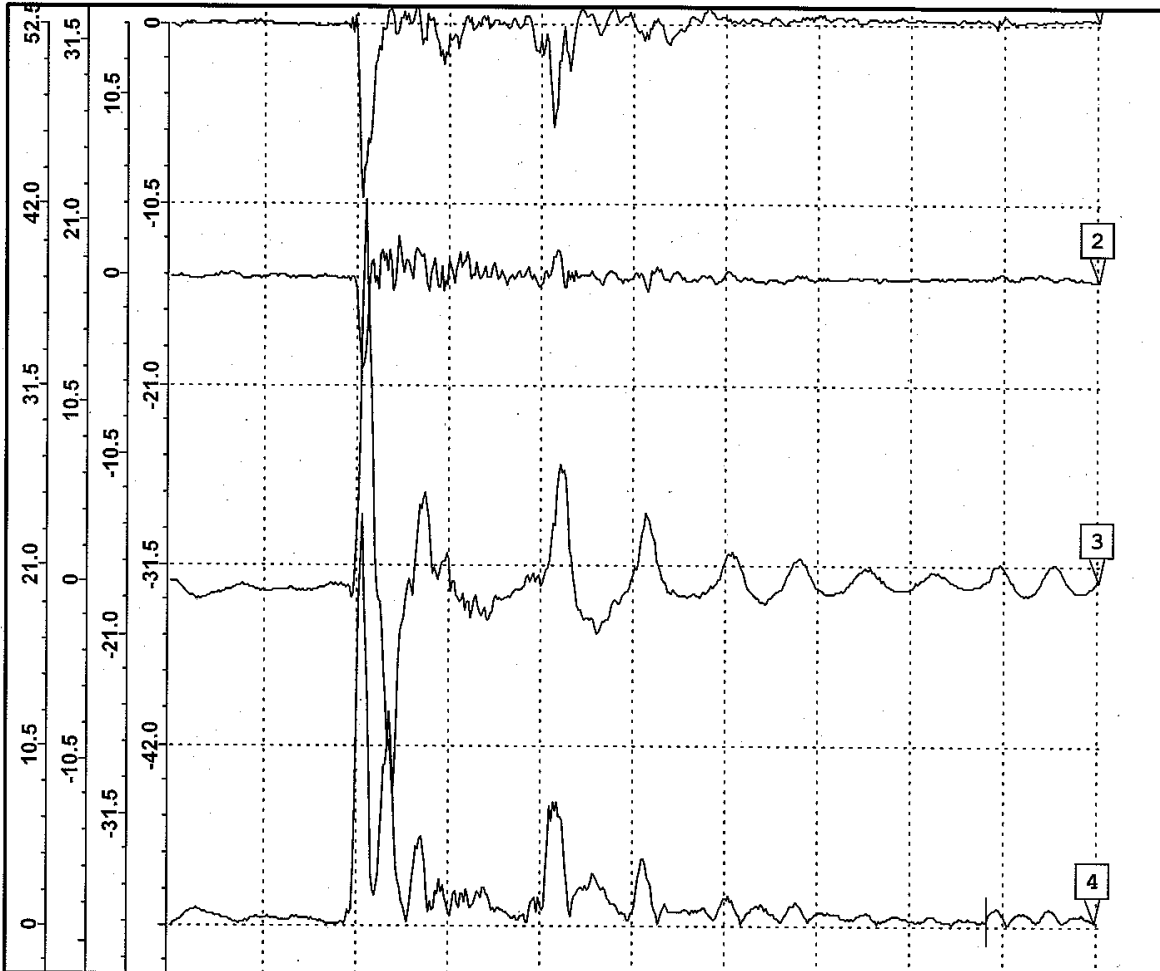
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16471.

Reaper Propeller

ROTATIONAL DROPS TEST

Time: Oct 6 2006 9:37 Test Engineer: Evans
Test Type: Corner, -40°F Impact Point: Forward left corner
Container/Item: Aluminum/Propeller Drop Height: 15 inches

V. Angle: 12.01; H. Angle: 94.29;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	1.15 S	0.35 g's	-10.15 g's	-61.11 In/s	131 mS	1	2
2	1.15 S	-0.01 g's	-5.91 g's	19.46 In/s	131 mS	1	2
3	1.15 S	0.07 g's	22.19 g's	8.28 In/s	131 mS	1	2
R	1.15 S	0.43 g's	23.95 g's	64.67 In/s	131 mS	1	2

Remarks

Peak Gs X: 10 Y: 6 Z: 22 Peak Gs Resultant: 24

Ch.1=X(aft, right corner); Ch.2=Y(right, frwd corner); Ch.3=Z(vert).
Ch.4=Resultant.

Aft Side = desiccant port side.

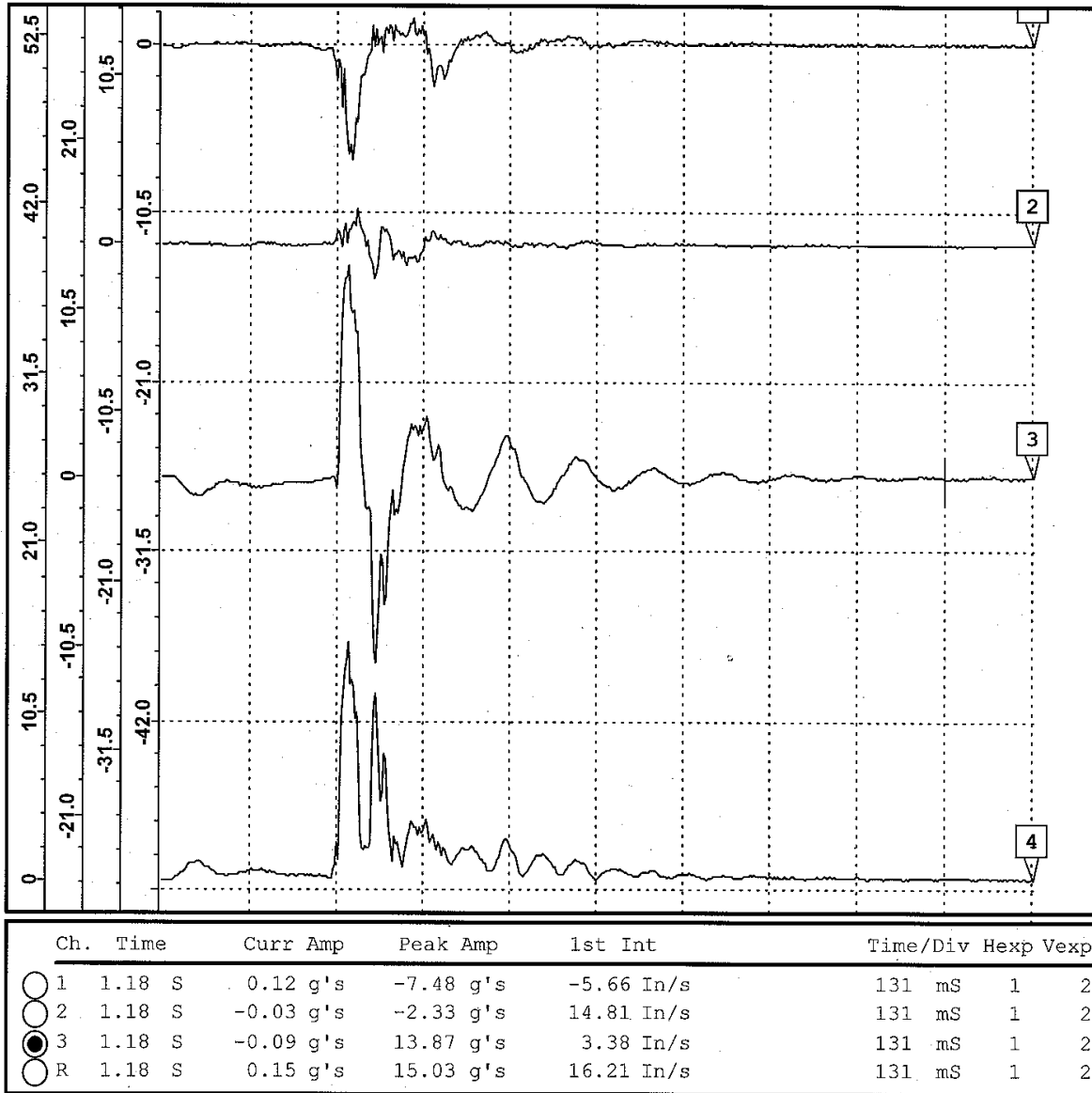
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16471.

Reaper Propeller

ROTATIONAL DROP TEST

Time: Oct 10 2006 9:40 Test Engineer: Evans
Test Type: Edge, +140°F Impact Point: Forward bottom edge
Container/Item: Aluminum/Propeller Drop Height: 15 inches

V. Angle: 37.78; H. Angle: 253.74;



Remarks

Peak Gs X: 7 Y: 2 Z: 14 Peak Gs Resultant: 15

Ch.1=X(aft, right corner); Ch.2=Y(right, frwd corner); Ch.3=Z(vert).
Ch.4=Resultant.

Aft Side = desiccant port side.

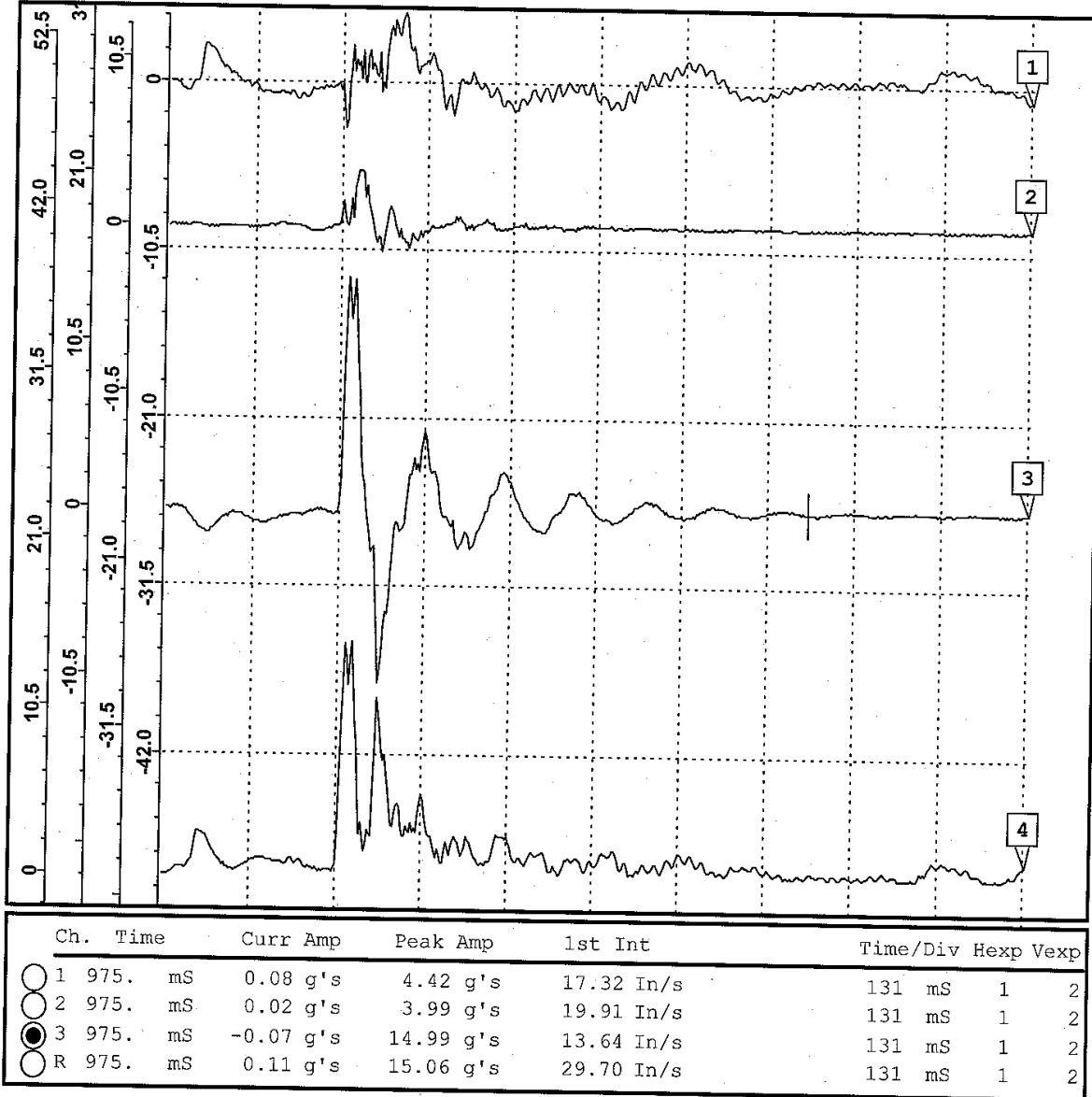
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16471.

Reaper Propeller

ROTATIONAL DROP TEST

Time: Oct 11 2006 12:50 Test Engineer: Evans
Test Type: Edge, +140°F Impact Point: Right bottom edge
Container/Item: Aluminum/Propeller Drop Height: 15 inches

V. Angle: 41.84; H. Angle: 285.64;



Remarks

Peak G X: 4 Y: 4 Z(vert): 15 Peak G Resultant: 15

Ch.1=X(aft, right corner); Ch.2=Y(right, frwd corner); Ch.3=Z(vert).
Ch.4=Resultant.

Aft Side = desiccant port side.

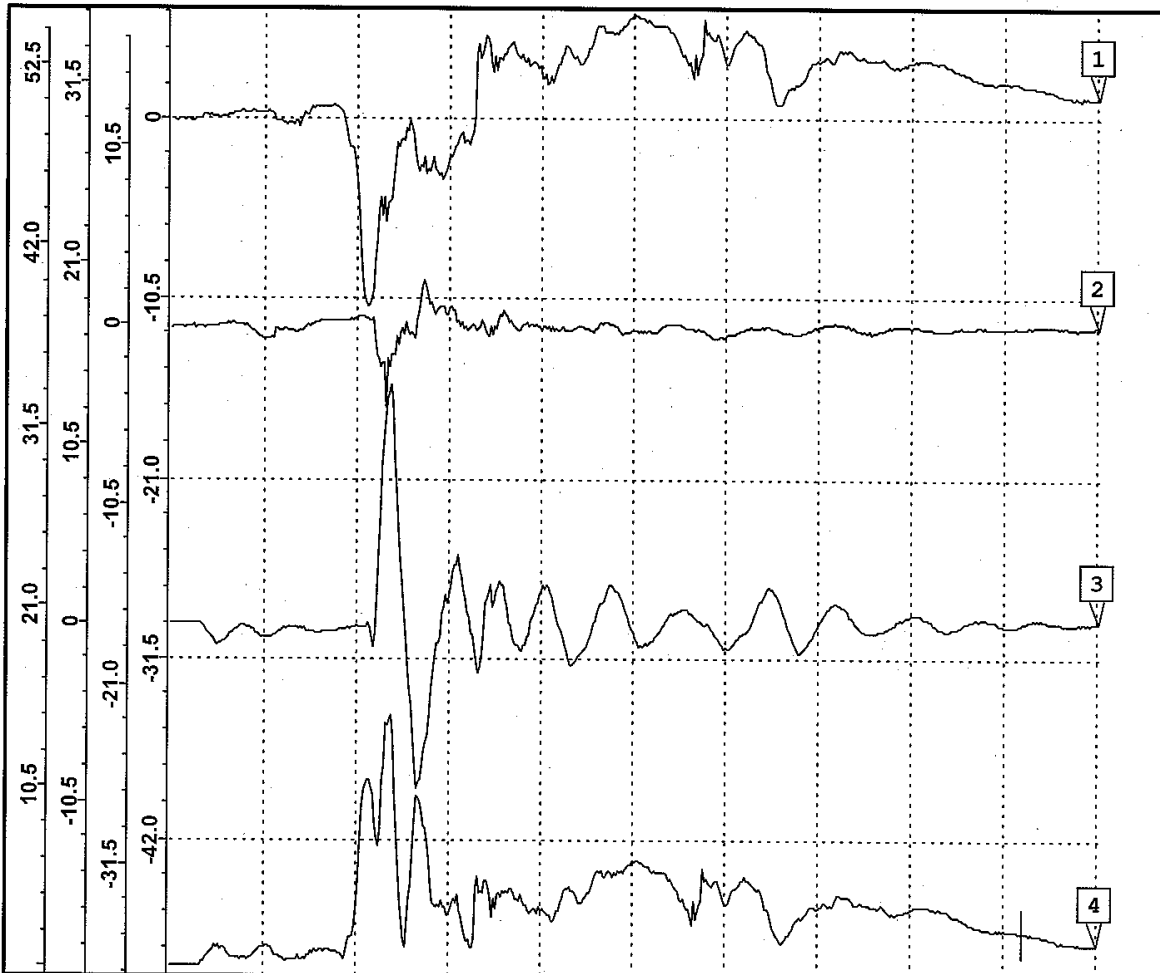
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16471.

Reaper Propeller

ROTATIONAL DROP TEST

Time: Oct 10 2006 9:27 Test Engineer: Evans
Test Type: Corner, +140°F Impact Point: Aft left corner
Container/Item: Aluminum/Propeller Drop Height: 15 inches

V. Angle: 4.34; H. Angle: 196.09;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	1.20 S	1.96 g's	-11.16 g's	859.07 In/s	131 mS	1	2
2	1.20 S	-0.14 g's	-4.78 g's	-35.91 In/s	131 mS	1	2
3	1.20 S	-0.04 g's	13.87 g's	11.00 In/s	131 mS	1	2
R	1.20 S	1.91 g's	14.82 g's	859.89 In/s	131 mS	1	2

Remarks

Peak G X: 11 Y: 5 Z(vert): 14 Peak G Resultant: 15

Ch.1=X(aft, right corner); Ch.2=Y(right, frwd corner); Ch.3=Z(vert).
Ch.4=Resultant.

Aft Side = desiccant port side.

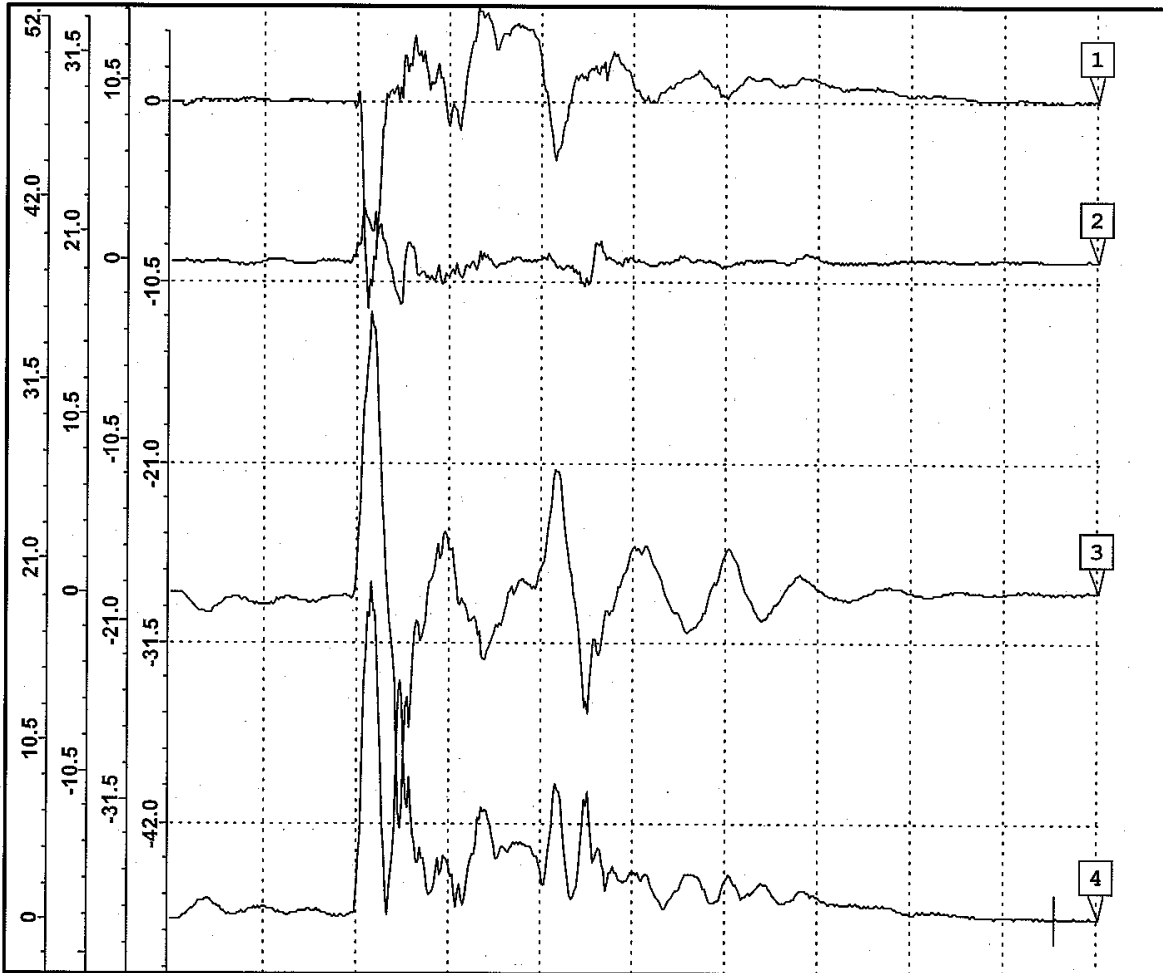
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16471.

Reaper Propeller

ROTATIONAL DROP TEST

Time: Oct 10 2006 9:37 Test Engineer: Evans
Test Type: Corner, +140°F Impact Point: Forward right corner
Container/Item: Aluminum/Propeller Drop Height: 15 inches

V. Angle: 87.80; H. Angle: 274.40;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	1.25 S	0.00 g's	-11.96 g's	320.61 In/s	131 mS	1	2
2	1.25 S	0.01 g's	-4.01 g's	-4.41 In/s	131 mS	1	2
3	1.25 S	-0.10 g's	16.83 g's	2.16 In/s	131 mS	1	2
R	1.25 S	0.10 g's	20.17 g's	320.65 In/s	131 mS	1	2

Remarks

Peak Gs X: 12 Y: 4 Z: 17 Peak Gs Resultant: 20

Ch.1=X(aft, right corner); Ch.2=Y(right, frwd corner); Ch.3=Z(vert).
Ch.4=Resultant.

Aft Side = desiccant port side.

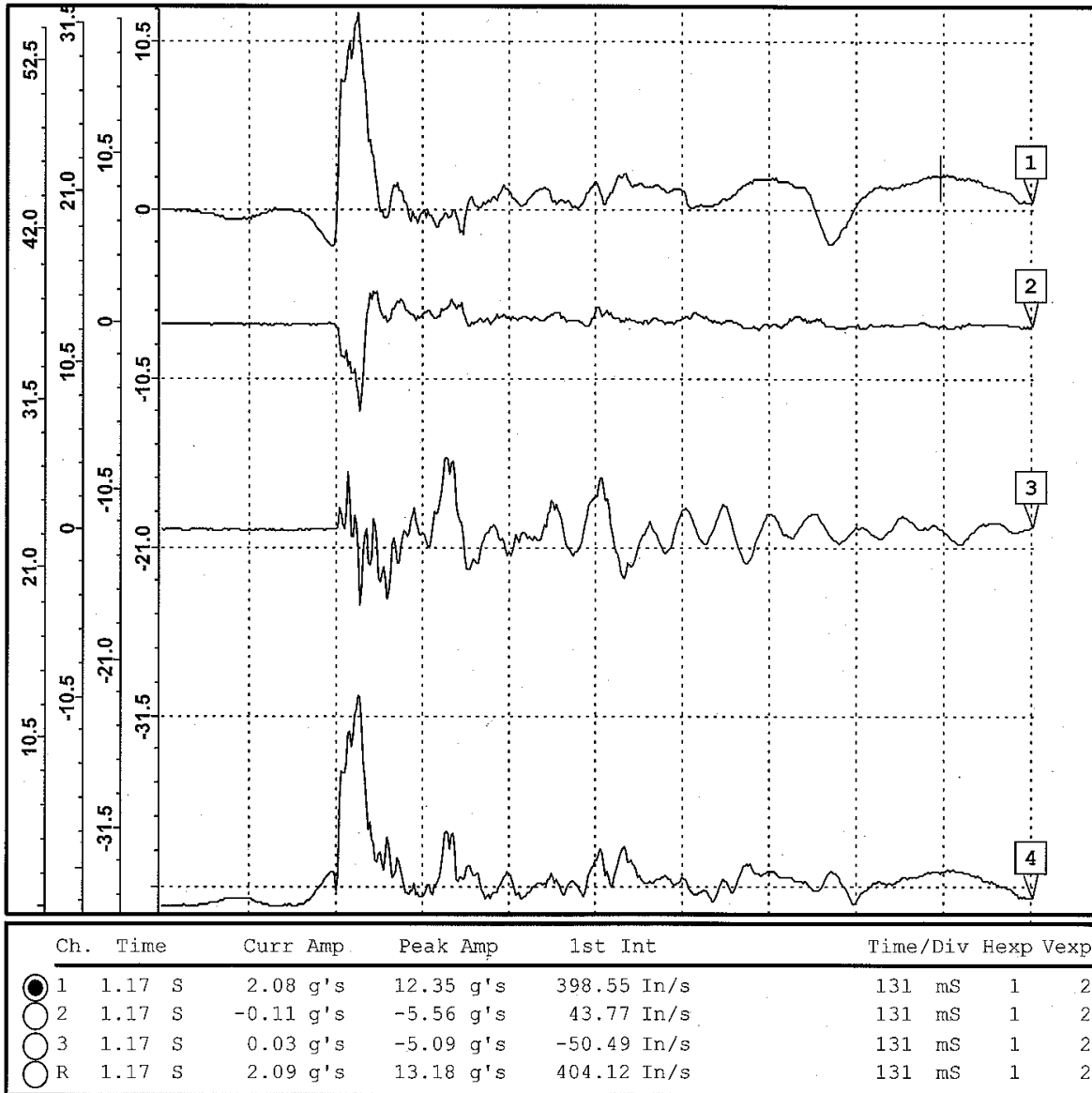
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16471.

Reaper Propeller

PENDULUM IMPACT TEST

Time: Oct 19 2006 14:00 Test Engineer: Evans
Test Type: Side, -40°F Impact Point: Aft side
Container/Item: Aluminum/Propeller Impact Velocity 7.3 ft/s

V. Angle: 3.14; H. Angle: 164.18;



Remarks

Peak Gs X: 12 Y: 6 Z: 5 Peak Gs Resultant: 13

Ch.1=X(aft, right corner); Ch.2=Y(right, frwd corner); Ch.3=Z(vert).
Ch.4=Resultant.

Aft Side = desiccant port side.

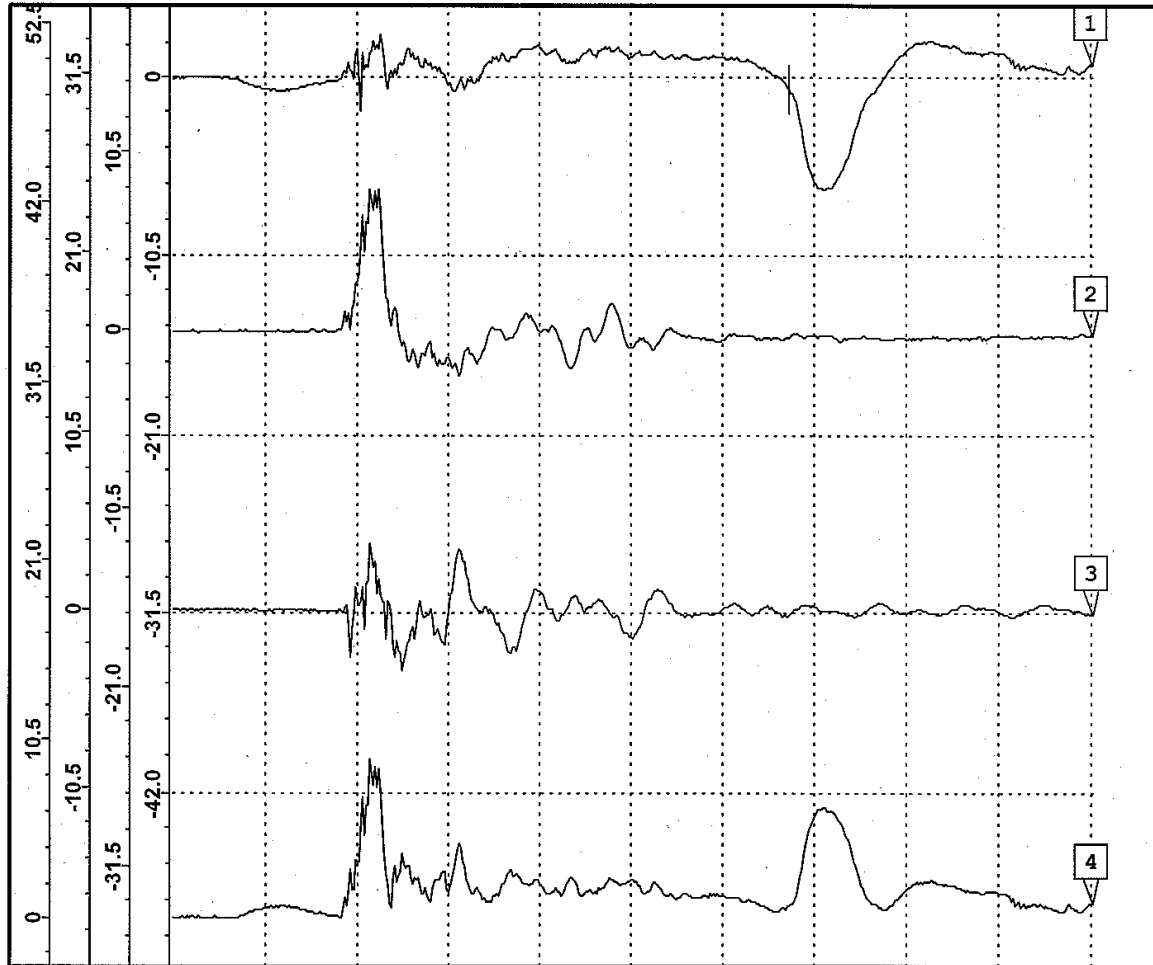
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16471.

Reaper Propeller

PENDULUM IMPACT TEST

Time: Oct 19 2006 13:53 Test Engineer: Evans
Test Type: Side impact, -40°F Impact Point: Right side
Container/Item: Aluminum/Propeller Impact Velocity 7.3 ft/s

V. Angle: 146.24; H. Angle: 219.32;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	878. mS	-0.62 g's	3.39 g's	223.71 In/s	131 mS	1	2
2	878. mS	-0.32 g's	8.55 g's	13.14 In/s	131 mS	1	2
3	878. mS	-0.26 g's	4.09 g's	-27.61 In/s	131 mS	1	2
R	878. mS	0.74 g's	9.58 g's	225.79 In/s	131 mS	1	2

Remarks

Peak Gs X: 7 Y: 9 Z: 4 Peak Gs Resultant: 10

Ch.1=X(aft, right corner); Ch.2=Y(right, frwd corner); Ch.3=Z(vert).
Ch.4=Resultant.

Aft Side = desiccant port side.

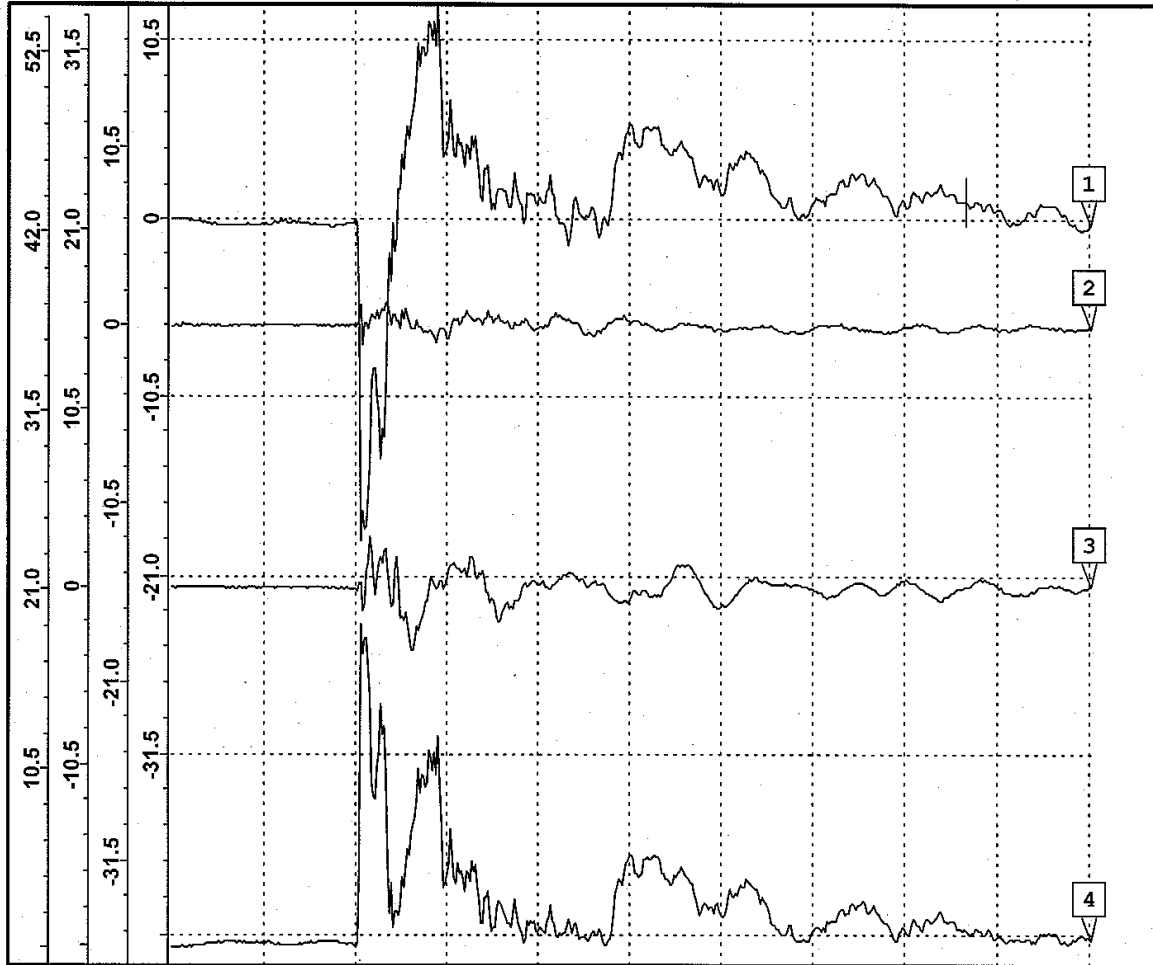
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16471.

Reaper Propeller

PENDULUM IMPACT TEST

Time: Oct 13 2006 13:10 Test Engineer: Evans
Test Type: Side impact, +140°F Impact Point: Forward side
Container/Item: Aluminum/Propeller Impact Velocity 7.3 ft/sec

V. Angle: 1.38; H. Angle: 164.36;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	1.13 S	0.99 g's	-19.22 g's	549.69 In/s	131 mS	1	2
2	1.13 S	-0.02 g's	1.65 g's	3.94 In/s	131 mS	1	2
3	1.13 S	0.01 g's	-3.88 g's	-9.29 In/s	131 mS	1	2
R	1.13 S	0.99 g's	19.22 g's	549.78 In/s	131 mS	1	2

Remarks

Peak G X: 19 Y: 2 Z(vert): 4 Peak G Resultant: 19

Ch.1=X(aft, right corner); Ch.2=Y(right, frwd corner); Ch.3=Z(vert).
Ch.4=Resultant.

Aft Side = desiccant port side.

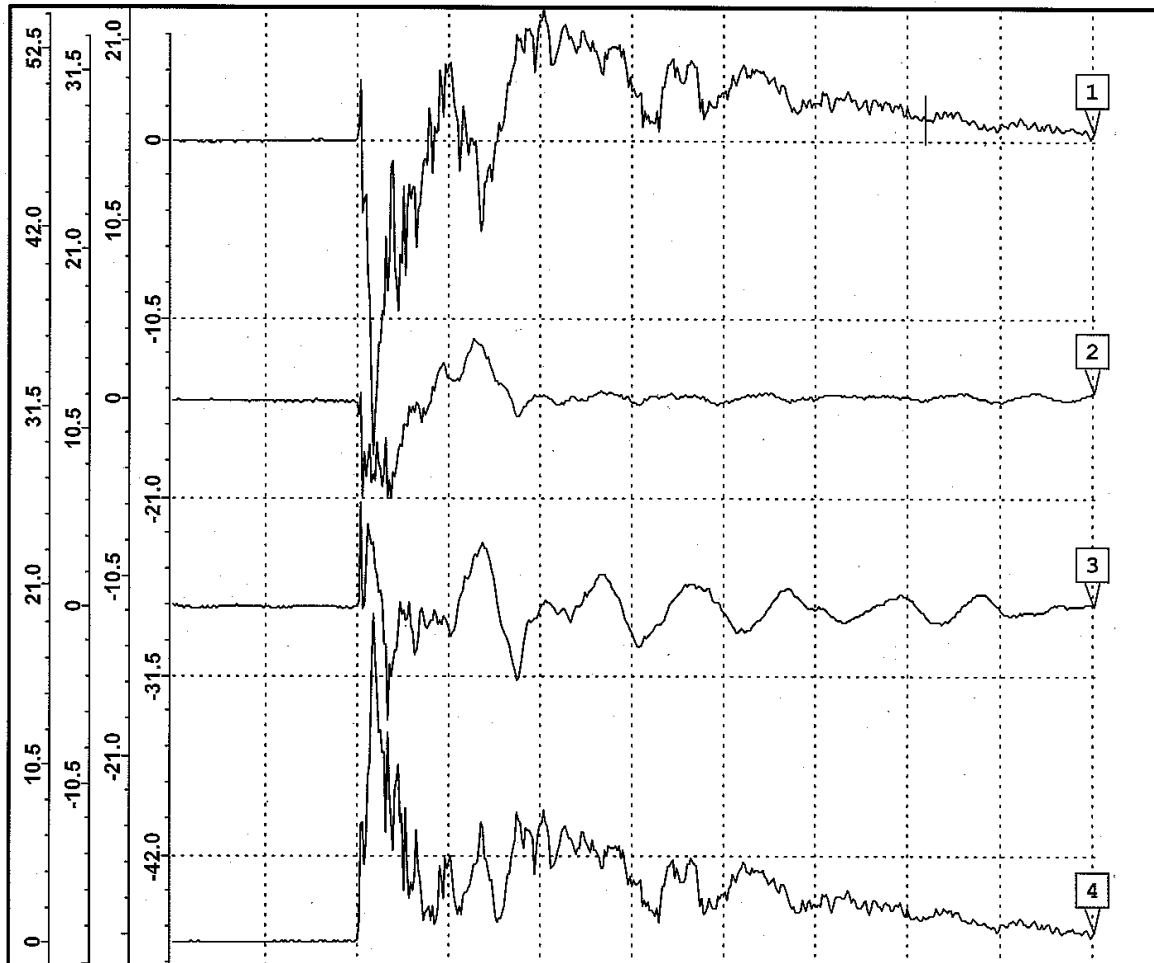
ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16471.

Reaper Propeller

PENDULUM IMPACT TEST

Time: Oct 11 2006 13:35 Test Engineer: Evans
Test Type: Side impact, +140°F Impact Point: Left side
Container/Item: Aluminum/Propeller Impact Velocity 7.3 ft/s

V. Angle: 22.25; H.Angle: 274.36;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	1.07 S	1.33 g's	-18.73 g's	592.60 In/s	131 mS	1	2
2	1.07 S	0.04 g's	-9.61 g's	-0.08 In/s	131 mS	1	2
3	1.07 S	-0.54 g's	-6.67 g's	-37.37 In/s	131 mS	1	2
R	1.07 S	1.43 g's	19.75 g's	593.78 In/s	131 mS	1	2

Remarks

Peak Gs X: 19 Y: 10 Z: 7 Peak Gs Resultant: 20

Ch.1=X(aft, right corner); Ch.2=Y(right, frwd corner); Ch.3=Z(vert).
Ch.4=Resultant.

Aft Side = desiccant port side.

ASTM D4169, ASTM D6179. SAE ARP 1967. Accelerometer S/N 16471.

APPENDIX 4: Test Instrumentation

PRESSURE TEST EQUIPMENT - Test sequences 1, 2, 7 & 8

EQUIPMENT	MANUFACTURER	MODEL	SN	CAL. DATE
Digital Manometer	Yokogawa	2655	82DJ6001	Aug 06
Digital Manometer	Yokogawa	2655	82DJ6009	Aug 06

ROUGH HANDLING TEST EQUIPMENT - Test sequences 3, 4, 5 & 6

EQUIPMENT	MANUFACTURER	MODEL	SN	CAL. DATE
Shock Amplifier	Endevco	2775A	ER34	NA
Shock Amplifier	Endevco	2775A	ER33	NA
Shock Amplifier	Endevco	2775A	EL81	NA
Item Accelerometer	Endevco	2228C	16471	Apr 06
Data Acquisition	GHI Systems	CAT	Ver. 2.7.1	N/A

APPENDIX 5: Distribution List

DISTRIBUTION LIST

DTIC/O
DEFENSE TECHNICAL INFORMATION CENTER
FORT BELVOIR VA 22060-6218

AFMC LSO/LO
WRIGHT-PATTERSON AFB OH 45433-5540

559 CBSS/GBLA (ATTN JEAN BAXTER)
7701 ARNOLD STREET.
BLDG 1, RM 112
TINKER AFB OK 73145

510 CBSS/GBMAD (ATTN THELMA LOOCK)
7973 UTILITY DRIVE
BLDG 1135
HILL AFB UT 84056

586 CBSS/GBMCAA (ATTN WAYNE OSBORN)
375 PERRY STREET
BLDG 255
ROBINS AFB GA 31098

658 AESS/LG (ATTN GERALD WILLIAMS)
2640 LOOP ROAD WEST
WRIGHT-PATTERSON AFB OH 45433-5540

GENERAL ATOMICS
ATTN DAVID LEVY
16761 VIA DEL CAMPO CT
SAN DIEGO CA 92127

APPENDIX 6: Report Documentation

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
<p>The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.</p> <p>PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.</p>					
1. REPORT DATE (DD-MM-YYYY) 21-02-2008		2. REPORT TYPE Technical, Final Project Report		3. DATES COVERED (From - To) March 06 - October 06	
4. TITLE AND SUBTITLE Development of the MQ-9 Reaper Propeller Container				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Joel A. Sullivan, Project Engineer joel.sullivan@us.af.mil, DSN 787-8162, Comm. (937) 257-8162 Susan J. Evans, Qualification Test Engineer susan.evans@us.af.mil, DSN 787-7445, Comm. (937) 257-7445				5d. PROJECT NUMBER 06-P-105	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Force Packaging Technology and Engineering Facility AFMC LSO/LOP 5215 THURLOW ST, STE 5, BLDG 70C WRIGHT-PATTERSON AFB OH 45433-5540				8. PERFORMING ORGANIZATION REPORT NUMBER 08-R-02	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT The Air Force Packaging Technology Engineering Facility (AFPTEF) was tasked with the design of a new shipping and storage container for the MQ-9 Reaper Propeller in March of 2006. The new container is designed to replace the fiberglass container currently used. The current container provides minimal shock protection and being fiberglass is susceptible to deformation, delamination, and extreme temperatures. Additionally, the fiberglass container can not house the propeller and spinner when the spinner is disassembled, the preferred shipping configuration. AFPTEF used proven design techniques to meet these design requirements. The CNU-690/E, designed to SAE ARP1967A, is an aluminum, long-life, controlled breathing, reusable shipping and storage container. The new container protects the Propeller mechanically and environmentally. The container passed all qualification tests per ASTM D4169. The CNU-690/E container not only meets user requirements but also provides an economic saving for the Air Force. The savings will be thousands of dollars per Propeller over the twenty-year life span of the container.					
15. SUBJECT TERMS CNU-690/E, MQ-9 Reaper Propeller Container, Aluminum Container, Reusable Container, Design, Test, Long Life					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES 38	19a. NAME OF RESPONSIBLE PERSON Joel A. Sullivan
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER (Include area code) (937) 257-8162